What is claimed is:

Claims

1. A microoptic element with synthetic birefringence for modifying the transmission characteristics of an input optical beam comprising first and second polarization beam splitter devices, wherein the first polarization beam splitter device separates the input beam into first and second orthogonally polarized output beams along first and second beam paths, a first non-birefringent optical delay line in the first beam path arranged such that the first beam undergoes a first time delay, a second non-birefringent optical delay line in the second beam path arranged such that the second beam undergoes a second time delay, different from the first, with the time delay difference being precisely determined by optical path length difference between the optical delay lines, and the second polarization beam splitter device being arranged to recombine the first and second delayed beams into a single beam having interfering components defining the desired modification in transmission characteristic

2. An element in accordance with claim 1 wherein the delay lines are glass elements interposed in each beam path and the glass elements are selected to provide athermal time delay difference characteristics between the two paths.

3. An element in accordance with claim 2 above, wherein the glass elements have substantially like thermal expansion coefficients selected to maintain the optical path length difference substantially constant over a selected range of temperature variations.

4. An element in accordance with claim 1 wherein the optical delay lines comprise first and second glass elements in the first and second beam paths respectively,

the first and second glass elements having approximately the same physical length and different optical indices of refraction providing the chosen time delay.

5. An element in accordance with claim 4 above, wherein the difference in index of refraction is in excess of about 15%.

6. An element in accordance with claim 5 wherein the first glass has an index of refraction of about 1.5 and the second glass has an index of refraction of about 1.9.

7. An element in accordance with claim 1 wherein the lengths of the first and second beam splitters are matched to within 250 microns.

8. An element in accordance with claim 1 wherein the physical lengths of the first and second beam splitters are nominally 6 to 10 mm.

9. An element in accordance with claim 1 wherein the first and second beam splitters are fabricated from YVO4 crystalline material

10. An element in accordance with claim 1, wherein the element comprises a number of serial stages each providing a time delay difference which is an integer multiple of a selected value, and each stage has an athermal response over a selected range of temperatures.

11. An element in accordance with claim 10 wherein the microoptic element includes waveplates disposed in the beam paths at predetermined angles selected to tune the transmission characteristics to a desired optical transfer function.

12. An element in accordance with claim 10 wherein each stage includes a half waveplate oriented at 45 degrees to the vertical axis.

13. An element in accordance with claim 10 further including a phase shifting tuning structure inserted in both the first and second beam paths, said tuning structure

comprising:

a first quarter or three quarter waveplate oriented at ±45 degrees;

at least one half waveplate whose orientation is rotatable to align the absolute frequency of output transmission peaks to match a target frequency grid; and

a second quarter or three quarter waveplate.

14. An element in accordance with claim 1 above wherein said difference in optical path lengths is proportional to $\frac{c}{\Delta f}$, where Δf is the frequency period of the optical transmission response.

15. An element in accordance with claim 1 above, wherein one delay line includes at least two nonbirefringent glass elements in series, wherein the beam paths include air paths between elements, and wherein the difference in air path lengths between the two beams is less than 600 microns.

16. An element in accordance with claim 1 wherein at least one delay line comprises an airspaced delay line providing a precise amount of optical path length difference between the first and second beam paths.

17. An element in accordance with claim 16 above, wherein one of the delay lines comprises at least one glass element and the other of the delay lines comprises at least one air delay line element.

18. An element as set forth in claim 1 above, wherein the element comprises a number of elements in cascading stages and the stages include means for compensating existing chromatic dispersion comprising:

means disposed in the elements in the cascading stages and responsive

to polarization of the beams for canceling the dispersion slope and providing substantially constant dispersion.

19. An element as set forth in claim 18 above, wherein the means for compensating chromatic dispersion includes means in association with the stages for controlling the polarization vector angles into the stages.

20. An element as set forth in claim 1 above, including third, fourth and fifth polarization beam splitter elements, the third polarization beam splitter being disposed before the first to split the first input beam into upper and lower orthogonally polarized beam pairs for differential delay, wherein the fourth polarization beam splitter device receives the beam pairs after differential delay, to provide two pairs of wavelength dependent intensity modulated beams of orthogonal polarization and the fifth polarization beam splitter device is disposed after the fourth polarization beam splitter to combine the power of the pairs of orthogonally polarized, intensity modulated beams.

21. An element as set forth in claim 20 above, wherein the element includes wavelength tuning elements in the beam paths associated with the optical delay lines.

22. An element as set forth in claim 21 above, wherein the wavelength tuning elements comprise rotatably adjustable waveplates.

23. An element as set forth in claim 1 above wherein at least one polarization beam splitter is angled relative to the input beam to adjust frequency period.

24. A system for dividing a number of signals periodically spaced in optical frequency propagating on an input waveguide into two sets of signals each having twice the periodic frequency spacing, with the frequencies in the two sets being in alternating relation, comprising:

an input polarization beam splitter coupled to receive the input optical frequencies, the input polarization splitter providing two differently polarized beams as outputs;

a second polarization beam splitter disposed to split each polarized beam into a pair of adjacent beams of orthogonal polarization;

a differential delay stage of two parallel optical delay paths each having at least one non-birefringent optical delay element, the indices of refraction and the lengths of the delay elements in each of the paths being chosen such that the optical signals of different polarizations are differentially retarded in the two pairs of beams by selected amounts relative to the desired periodic spacings;

a polarization combiner receiving the delayed signals from the two paths of the delay stage for combining beams to produce periodic, wavelength dependent states of polarization of selected optical frequency and phase, and

an output polarization combiner responsive to products of the combined beams for recombining beams of different polarizations into two separate intensity modulated outputs, each providing one different frequency set.

25. A system as set forth in claim 24 above, wherein at least one delay element is glass.

26. A system as set forth in claim 24 above, wherein the system provides passbands of selected frequencies in accordance with a selected ITU grid and the optical delay elements and the delay stage includes air length segments in each path, with the optical delay elements and air length segments in each path being interrelated to provide an athermal response to temperature variations over a selected range.

27. A system as set forth in claim 24 above, wherein the differential delay stage comprises delay elements of non-birefringent glass of different indices of refraction.

28. A system as set forth in claim 24 above, wherein the differential delay stage comprises a pair of glass elements serially disposed in one path and a single glass element disposed in the other.

29. A system as set forth in claim 24 above, wherein the input beam splitting polarizer divides the input into extraordinary and ordinary polarization beams for the two optical paths, and wherein the differential delay stage comprises polarization vector control means for phase tuning the transmission characteristics of the stage.

30. A system as set forth in claim 24 above, wherein at least one of the polarization beam splitters is angled relative to the beam direction to adjust the frequency period of the outputs.

31. A system as set forth in claim 24 above, wherein at least one of the differential delay stages includes an air delay line element.

32. A system as set forth in claim 31 above, wherein the differential delay stage comprises a first path having a non-birefringent glass element and a second path having a closed loop of reflecting elements providing a complete circuit of selected optical path length.

33. A system as set forth in claim 24 above, wherein the system further includes, in each beam path in association to the differential delay stage, elements imparting circular polarization to the beams, waveplate frequency adjusting means receiving the circularly polarized signals, and polarizing means receiving the frequency adjusted signals.

34. A microoptic element providing synthetic birefringence to apply a filtering function to an optical input beam comprising:

an input polarization beam splitter means receiving optical input beam and providing as outputs two differently polarized beams;

two signal delay paths, each comprising at least one non-birefringent optical element and receiving a different one of the differently polarized beams, the said non-birefringent elements having different selected indices of refraction and physical lengths accurate within ±1 micron of calculated lengths such that a precise relative retardation is introduced; and

an output polarization beam splitter receiving both beams and combining them.

35. A microoptic element as set forth in claim 34 above, wherein the difference in indices of refraction between the non-birefringent elements is greater than 15%, and wherein the non-birefringent elements are of glass and of substantially equal lengths between the two paths.

36. A microoptic element as set forth in claim 35 above, wherein the optical delays provide selected periodic bandpass functions in the optical input signals, and wherein the periodicity of the bandpass functions align the bandpass regions with respect to ITU grid standards.

37. A microoptic element as set forth in claim 36 above, wherein the indices of refraction are chosen such that the element has differential optical paths varying to less than 1 part in 10^4 relative to a selected ITU grid periodicity, and the individual elements are of less than 20 mm in length.

38. A microoptic element as set forth in claim 37 above, wherein the signal delay paths comprise several stages each having at least one glass element, the first stage elements having a length L and disposed in a series of n elements, where n is an integer of 1 or greater, and succeeding stages having total lengths that are integer multiples of nL in length.

39. A microoptic element as set forth in claim 38 above, wherein the stages each include different glass elements selected to provide a passive athermal characteristic over a selected temperature range in each stage.

40. A microoptic element as set forth in claim 39 above, wherein the stages further include waveplate tuning elements for adjusting the periodicities of the outputs precisely to the ITU grid and the glass elements are 8-16 mm in length and the microoptic element is less than about 15 cm in total length.

41. A microoptic element as set forth in claim 40 above, wherein the output beam splitter comprises a first output beam splitter oriented to split each optical signal into two orthogonally polarized beams and a second output beam splitter orthogonally positioned relative to the first output beam splitter to recombine optical beam sets to polarization insensitive outputs.

42. A system for introducing a periodic transmissive function to an input optical beam of an arbitrary state of polarization having wavelength multiplexed channels comprising:

at least a first beam splitter arrangement receiving the optical beam and providing two beam pairs of different polarizations;

a pair of polarization insensitive optical delay lines, each in the path of a different beam, and introducing selected differential optical delays between beam pairs to provide wavelength dependent, polarization modulated beams carrying the multiplexed channels; and

at least a second beam splitter arrangement receiving the different beams from the delay lines and combining them to form a wavelength dependent, polarization modulated beams which transmit multiplexed channels of different spacings than the input.

43. A system as set forth in claim 42 above, wherein the optical delay lines comprise non-birefringent elements of substantially like physical lengths and different indices of refraction.

44. A system as set forth in claim 42 above, wherein the optical delay lines in the different paths are glass elements selected to have like optical path length changes with temperature.

45. A system as set forth in claim 44 above, wherein the glass elements are of lengths and refractive indices selected to compensate for thermal expansion and thermooptic effects along the two beam paths.

46. A system as set forth in claim 42 above, wherein the optical delay lines are arranged in at least two stages with integer related optical delay differential characteristics whose total differential optical lengths vary by integral multiples such that transmission passbands are shaped to selected characteristics.

47. A system as set forth in claim 42 above, wherein the system comprises in addition at least one additional stage of a pair of polarization insensitive optical delay lines in series with the first pair, input polarization management optics associated with the first

beam splitter arrangement for launching a pair of identically polarized beams into the first optical delay line pair, and output polarization management optics associated with the second beam splitter arrangement for separating an identically polarized beam pair into alternate channels and combining them to provide polarization independent outputs.

48. A multistage optical signal interleaver providing periodically spaced passbands to one or more outputs from an input multiwavelength optical signal having an arbitrary state of polarization comprising:

a first polarization beam splitter combination receiving the input optical signal and providing two spaced apart, substantially parallel beam pairs, the beams of each pair being orthogonally polarized;

one or more stages of microoptic elements of non-birefringent characteristics, each receiving the beams from the first polarization beam splitter combination and configured with separate beam paths having selected differential optical retardation characteristics defining predetermined periodically spaced passbands, the outputs from the beam paths having selected polarizations;

a second polarization beam splitter combination receiving the outputs from the beam paths and combining differentially retarded beams from each of the two beam pairs to provide beams having wavelength dependent states of polarization; and

a third polarization beam splitter combination receiving the beams from the second polarization beam splitter combination and combining the beams to form first and second output beams including first and second intensity modulated output beams having transmissive passbands at selected periodically spaced channels, the channels alternating between the output beams.

49. An interleaver as set forth in claim 48 above, wherein the orthogonally polarized beams received by the non-birefringent microoptic elements are linearly polarized.

50. An interleaver as set forth in claim 49 above, wherein the beams in the non-birefringent optical elements in each path are similarly polarized, but beams in the separate paths are orthogonally related with the orthogonality relationship being reversed between successive stages.

51. An interleaver as set forth in claim 48 above, wherein the orthogonally polarized beams received by the non-birefringent microoptic elements are circularly polarized to reduce back reflection and ripple.

52. An interleaver as set forth in claim 51 above, wherein the beams in the non-birefringent elements in one path are similarly circularly polarized, while beams in the other path are oppositely circularly polarized.

53. An interleaver as set forth in claim 48 above, wherein the interleaver further includes first ¼ or ¾ waveplate means disposed in association with at least one of the stages for converting beams of linear polarization to circular polarization, and half waveplate means disposed in the path of the beams of circular polarization for varying the relative phase between the two beams propagating along parallel paths.

54. An interleaver as set forth in claim 53 above, wherein the half waveplate means comprises a pair of serially disposed angularly adjustable half waveplates, each separately intercepting a different differentially retarded pair of beams from the separate beam paths, and the interleaver further includes a second ¼ or ¾ waveplate means after the half wavelength means for restoring the circular polarizations

to linear polarizations.

55. A signal interleaver in accordance with claim 48, wherein the microoptic elements of the stages comprise non-birefringent glass elements of at least two different glasses of different indices of refraction in each of the different optical paths, the indices and lengths of the glass elements being chosen to provide selected optical path lengths in each stage that are passively athermal over a selected temperature range.

56. A signal interleaver in accordance with claim 55 above, wherein the stages are arranged with optical path lengths and relative angles of polarization of the beams to the microoptic elements selected to flatten the periodically spaced passbands, and increase channel isolation between passbands.

57. A signal interleaver in accordance with claim 55 above, wherein the beams in the glass elements comprise upper and lower pairs and the interleaver further includes waveplates disposed in the upper and lower beam paths for matching optical path lengths to minimize PMD.

58. A compact optical interleaving filter component for a WDM input beam comprising:

an input fiber optic collimator directing the input beam into the component;

an input polarization beam splitter receiving the collimated beam and producing two orthogonally polarized beams traveling along parallel paths;

an input waveplate array to convert the two orthogonally polarized beams into two beams of identical polarization;

an intermediate polarization beam splitter receiving the beams from the delay line elements and configured to separate each of the two beams of identical polarization

into a pair of orthogonally polarized beams;

at least two microoptic delay line stages having parallel optical delay line elements of nominal difference D*l* and 2D*l* in optical path length, the stages being disposed in series and separately differentially delaying the pairs of orthogonally polarized beams without using intrinsic material birefringence, the delay line stages including polarization rotating elements disposed at angles selected to adjust the optical frequency transmissive characteristic imparted to the two different beam pairs independently of the differential delays, and by separately rotating the polarizations of two pairs of the beams to selected angles;

an output polarization beam splitter after the final one of the stages to recombine each of the two beams of a pair into a single different combined output beam; and

output optics receiving the one or more output beams and including folding optics and output collimators arranged to direct the one or more output beams into the one or more output fiber optic collimators.

59. An interleaving optical filter in accordance with claim 58, wherein the input waveplate array is oriented to minimize PMD by balancing the optical path lengths traversed by the two beams.

60. An interleaving optical filter in accordance with claim 58, wherein the total optical length difference D*l* is equal to 12 mm for a 25 GHz interleaver.

61. An interleaving optical filter in accordance with claim 58 wherein the total optical path length difference D*l* is equal to 6 mm for a 50 GHz interleaver.

62. An interleaving optical filter in accordance with claim 58, wherein the total optical path length difference D/ is equal to 3 mm for a 100 GHz interleaver.

63. An interleaving optical filter in accordance with claim 58, wherein the total optical path length difference D/ is equal to 24 mm for a 12.5 GHz interleaver.

64. An interleaving optical filter in accordance with claim 58, wherein the polarization rotating elements are half waveplates which are disposed between the first and second interleaver stages at angles of –31.0 ±1 degrees and between the second and third interleaver stages at angles of 13.1 ±1 degrees.

65. A multistage optical signal interleaver for demultiplexing DWDM channels at a single beam terminal into odd and even output channels at second and third beam terminals or alternatively multiplexing odd and even input channels at the second and third terminals into a composite output beam at the first beam terminal comprising:

a first polarization beam splitter combination having a first terminal coupled to the single beam terminal and a pair of spaced apart beam terminals separate from the first terminal;

at least two stages of non-birefringent microoptic elements disposed serially along a beam delay path, each stage including separate beam paths having selected optical path length characteristics providing a chosen differential retardation between beams on the different paths, one serial terminus of the stages being in communication with the pair of terminals of the first polarization beam splitter, the other serial terminus providing a pair of beam ports;

an additional polarization beam splitter coupled optically between the pair of beam ports and the second and third terminals.

66. An interleaver as set forth in claim 65 above, wherein each stage includes polarization beam splitter means arranged to direct at least two beam pairs through the stages, and each beam delay path includes a waveplate combination for phase tuning to selected channel placements.

67. An interleaver as set forth in claim 66 above, wherein the non-birefringent optical elements comprise glass elements substantially of basic length L, and wherein channel spacing is defined by serial disposition in the stages of integer multiples of elements of the basic length and frequency period is adjusted by angling at least on polarization beam splitter.

68. An interleaver as set forth in claim 64 above, wherein the stages comprise three stages of total lengths L, 2L and 2L for a 50 GHz interleaver, where n is a length selected for a 100 GHz interleaver.

69. An interleaver as set forth in claim 64 above, wherein the stages comprise two stages of nominal total lengths 2L and 4L for a 25 GHz interleaver, where n is a length selected for a 100 GHz interleaver.

70. An interleaver as set forth in claim 64 above, wherein the stages comprise two stages of nominal total lengths 4L and 8L for a 12.5 GHz interleaver, where n is a length selected for a 100 GHz interleaver.

71. A method of providing an interleaved optical frequency response for filtering WDM channels carried by a polarized or unpolarized optical beam comprising the steps of:

splitting the input beam into linearly and orthogonally polarized beams spaced apart in a first direction;

rotating the state of polarization of at least one of the beams so they become identically polarized;

rotating the states of polarization of both beams by a first angle;

splitting each of the beams in a second direction orthogonal to the first while introducing an orthogonal polarization relationship therebetween;

applying different phase delays to beam pairs separated in the second direction while leaving the states of polarization unchanged;

separately phase tuning the beam pairs separated in the first direction to adjust the absolute frequency of transmissive peaks in passage along the beam paths;

tuning the frequency period of the transmissive peaks separately from the phase tuning;

combining each pair of beams in the second direction to produce two periodic, wavelength dependent state of polarization beams with first optical frequency and phase;

rotating the states of polarization of each of the combined beams by a second angle;

repeating at least once the sequence from splitting the beams to producing periodic, wavelength dependent, states of polarization beams having selected optical frequency and phase, while converting the last pair of periodic, wavelength dependent states of polarization to a pair of output beams with wavelength dependent intensities which are in independent of polarization.

72. A method as set forth in claim 71 above, wherein the step of applying

different phase delays to beam pairs is effected with the orthogonal beams being circularly polarized.

73. A method as set forth in claim 71 above, wherein the step of phase tuning is employed in all but the last of the repeated sequences.

74. A method as set forth in claim 71 above, further including the steps of converting the beams from linear to circular polarizations prior to phase tuning, and converting circularly polarized beams to linearly polarized beams prior to combining each pair of beams separated in the first direction.

75. A method as set forth in claim 71 above, wherein the beams are converted to circular polarizations in opposite senses of circularity prior to applying different independent phase delays and converted back to linear polarizations after phase tuning.

76. A method as set forth in claim 71 above, wherein the step of tuning the frequency period is effected while splitting beams.

77. A method as set forth in claim 71 above, wherein the steps of applying different independent yet integer related phase delays are arranged to provide at least two successively narrower channel spacings whose channel spacings match the channel frequencies in the ITU grid.

78. A method of providing an interleaved optical frequency response for filtering DWDM channels carried by a polarized or an unpolarized beam utilizing a polarization interference filter with a polarization reference frame in which 0 degrees is defined as vertical and positive angles are defined as clockwise, comprising the steps of;

splitting the input beam into linearly and orthogonally polarized upper and lower beams;

rotating the state of polarization of the upper beam by 90 degrees so both upper and lower beams become identically polarized;

rotating the states of polarization of both upper and lower beams by a first angle;

splitting each of the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

applying a first wavelength dependent and polarization independent phase delay to the left beams while leaving the states of polarization unchanged;

applying a second wavelength dependent and polarization independent phase delay to the right beams while leaving the states of polarization unchanged, the first and second phase delays having a selected differential value;

converting the states of polarization of the left beams and right beams to circularly polarized light;

applying a first wavelength independent phase delay to the upper beams while preserving the circular state of polarization;

applying a second wavelength independent phase delay to the lower beams while preserving the circular state of polarization;

converting the state of polarization of the left beams to a linear state of polarization at 90 degrees and the right beams to a linear state of polarization at 0 degrees;

combining the lower right and left beams into a single lower beam to produce a periodic, wavelength dependent state of polarization with first optical frequency period and phase combining the upper right and left beams into a single upper beam to produce

the same periodic, wavelength dependent state of polarization with first optical frequency period and phase,

rotating the states of polarization of both upper and lower beams by a second angle;

splitting each of the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

applying a third wavelength dependent and polarization independent phase delay to the left beams while leaving the states of polarization unchanged;

applying a fourth wavelength dependent and polarization independent phase delay to the right beams while leaving the states of polarization unchanged, the third and fourth phase delays having a selected differential value;

converting the states of polarization of the left beams and right beams to circularly polarized light;

applying a third wavelength independent phase delay to the upper beams while preserving the circular states of polarization;

applying a fourth wavelength independent phase delay to the lower beams while preserving the circular states of polarization;

converting the states of polarization of the left beams to a linear state of polarization at 90 degrees and the right beams to a linear state of polarization at 0 degrees;

combining the lower right and left beams into a single beam to produce a periodic, wavelength dependent state of polarization with a second optical frequency period and phase having a selected relation to the first optical frequency period and phase;

combining the upper right and left beams into a single beam to produce a

corresponding periodic, wavelength dependent state of polarization having the second optical frequency period and phase,

rotating the states of polarization of both upper and lower beams by a third angle;

splitting the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

applying a fifth wavelength dependent and polarization independent phase delay to the left beams while leaving the states of polarization unchanged;

applying a sixth wavelength dependent and polarization independent phase delay to the right beams while leaving the states of polarization unchanged, the fifth and sixth phase delays having a selected differential value;

converting the states of polarization of the left beams and right beams to circularly polarized light;

applying a fifth wavelength independent phase delay to the upper beams while preserving the circular states of polarization;

applying a sixth wavelength independent phase delay to the lower beams while preserving the circular states of polarization;

converting the states of polarization of the left beams to a linear state of polarization at 90 degrees and the right beams to a linear state of polarization at 0 degrees;

combining the lower right and left beams into a single beam to produce a periodic, wavelength dependent state of polarization with second optical frequency period and phase;

combining the upper right and left beams into a single beam to produce the

same periodic, wavelength dependent state of polarization with second optical frequency period and phase;

rotating the states of polarization of upper and lower beams by a fourth angle;

splitting the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

rotating the states of polarization of the upper left and lower right beams by 90 degrees;

recombining the left beams into a single first output beam with periodic, frequency dependent transmission, and

recombining the right beams into a single second output beam with periodic, frequency dependent transmission, wherein the first output beam and second output beam exhibit polarization independence.

79. A method in accordance with claim 78 above, wherein the first angle is about 45.0°, the second angle is about 62.0°, the third angle is about 26.2°, the fourth angle is about 9.2°, the first optical frequency period is 100.00 GHz, the second optical frequency period is 50.00 GHz, and all the phases are selected to align the interleaver frequency responsively to the ITU grid.

80. A method in accordance with claim 78 above, wherein the first angle is about 45.0°, the second angle is about 62.0°, the third angle is about 26.2°, the fourth angle is about 9.2 degrees, the first optical frequency period is 200.00 GHz, the second optical frequency period is 100.00 GHz, and all the phases are selected to align the interleaver frequency response to the ITU grid.

81. A method in accordance with claim 78 above, including a final step of decoding wavelength dependent polarization modulation into wavelength dependent intensity modulation.

82. A method of providing an interleaved optical frequency response for filtering DWDM channels carried by a polarized or an unpolarized beam utilizing a polarization interference filter with a polarization reference frame in which 0 degrees is defined as vertical and positive angles are defined as clockwise is defined, comprising the steps of;

splitting the input beam into linearly and orthogonally polarized upper and lower beams;

rotating the state of polarization of upper beam by 90 degrees so both upper and lower beams become identically polarized;

rotating the states of polarization of both the upper and lower beams by a first angle;

splitting each of the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

applying a first wavelength dependent and polarization independent phase delay to the left beams while leaving the states of polarization unchanged;

applying a second wavelength dependent and polarization independent phase delay to the right beams while leaving the states of polarization unchanged, the first and second phase delays having a selected differential value;

converting the state of polarization of the left beams to a linear state of polarization at 90 degrees and the right beams to a linear state of polarization at 0 degrees;

combining the lower right and left beams into a single lower beam to produce a periodic, wavelength dependent state of polarization with first optical frequency period and phase

combining the upper right and left beams into a single upper beam to produce the same periodic, wavelength dependent state of polarization with first optical frequency period and phase;

rotating the states of polarization of both upper and lower beams by a second angle;

splitting each of the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

applying a third wavelength dependent phase delay to the left beams while leaving the states of polarization unchanged;

applying a fourth wavelength dependent and polarization independent phase delay to the right beams while leaving the states of polarization unchanged the third and fourth phase delays having a selected differential value;

converting the states of polarization of the left beams to a linear state of polarization at 90 degrees and the right beams to a linear state of polarization at 0 degrees;

combining the lower right and left beams into a single beam to produce a periodic, wavelength dependent state of polarization with second optical frequency period and phase having a selected rotation to the first optical frequency period and phase;

combining the upper right and left beams into a single beam to produce a corresponding periodic, wavelength dependent state of polarization having the second optical frequency period and phase,

rotating the states of polarization of both upper and lower beams by a third angle;

splitting the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

applying a fifth wavelength dependent and polarization independent phase delay to the left beams while leaving the states of polarization unchanged;

applying a sixth wavelength dependent and polarization independent phase delay to the right beams while leaving the states of polarization unchanged the fifth and sixth phase delays having a selected differential value;

converting the states of polarization of the left beams to a linear state of polarization at 90 degrees and the right beams to a linear state of polarization at 0 degrees;

combining the lower right and left beams into a single beam to produce a periodic, wavelength dependent state of polarization with second optical frequency period and phase;

combining the upper right and left beams into a single beam to produce the same periodic, wavelength dependent state of polarization with second optical frequency period and phase;

rotating the states of polarization of upper and lower beams by a fourth angle;

splitting the upper and lower beams into a left beam linearly polarized at 0 degrees and a right beam linearly polarized at 90 degrees;

rotating the states of polarization of the upper left and lower right beams by 90 degrees;

recombining the left beams into a single first output beam with periodic,

frequency dependent transmission, and

recombining the right beams into a single second output beam with periodic, frequency dependent transmission, wherein the first output beam and second output beam exhibit polarization independence.

83. The method of interleaving different frequency channels existing in a multiwavelength multiplexed optical input beam, while transmissively filtering the frequencies relative to target frequencies, comprising the steps of:

dividing the input beam into first and second optical beam pairs, the beams of each pair being orthogonally and linearly polarized;

differentially retarding the two beams within each pair by propagating them through polarization insensitive media;

differentially phase delaying beams of individual pairs to adjust transmissive peaks of each pair to target frequencies;

separately combining orthogonally polarized individual beams of each pair into single beams to produce two beams of periodic, wavelength dependent states of polarization of first optical frequency and phase.

84. The method of claim 83 above, further comprising the additional steps of again separating the two beams into pairs of beams of orthogonal and linear polarization;

and recombining the orthogonally polarized beams in each pair separately to provide first and second intensity modulated, periodic, frequency dependent transmissions spaced relative to the target frequencies.

85. The method of interleaving different frequency channels existing in a multiwavelength multiplexed optical signal, while transmissively filtering the frequencies relative to target frequencies, comprising the steps of:

separating the multiplexed optical signal into first and second input beams of identical polarization;

dividing the input beams into pairs with beams of orthogonal polarization;

differentially retarding beam pairs along separate optical paths;

separately combining individual beams adjacent from the two pairs to produced periodic, wavelength dependent states of polarization of first optical frequency and phase;

re-separating the two beams into pairs of beams of orthogonal polarization;

repeating the sequence of dividing the combined beams, differentially retarding, combining to produce additional optical transmission responses with periodic, wavelength dependent states of polarization with optical frequencies and phases selectively related to the first optical frequency and phase and re-separating into pairs of beams; and

after the last such sequence, transferring and directing the beams in each pair separately to produce two output beams with first and second intensity modulated, periodic, frequency dependent transmission.

86. The method as set forth in claim 85 above, including the further step of phase adjusting transmissive peaks by introducing phase delays between each pair of beams of orthogonal polarization.

87. The method as set forth in claim 85 above, wherein the steps of

differentially retarding further comprise maintaining the differential retardation substantially constant over a selected temperature range, and flattening the transmission peaks while increasing the rejection between the transmissive peaks.

88. The method as set forth in claim 85 above, including the further step of adjusting the frequency period while dividing or combining the beams.

89. The method of filtering a multiwavelength optical signal with an approximation of a square wave transmittance function matched to ITU wavelengths while separating the optical signal into two multiwavelength optical signals of like periodicities but offset in wavelength, comprising the steps of:

polarization splitting the optical beam into four different beams polarized orthogonally in two different pairs;

directing each pair of component beams through different polarization insensitive optical paths, the different paths having selected optical path length differences to synthesize birefringent delays;

converting the four beams to circular polarization;

applying differential retardation to the circularly polarized beams;

converting the four beams back to linear polarization states with polarizations rotated 90° in each pair from the original pairs; and

polarization combining the converted beams to provide two outputs whose states of polarization are wavelength dependent.

90. The method as set forth in 89 above, wherein the step of providing two outputs comprises providing separate outputs having transmissive peaks at double the periodicity of the original signal, with peaks from the two signals alternating in frequency.

91. A method of introducing a predetermined periodic transfer function in a multiwavelength optical beam comprising the steps of:

dividing the optical beams into two input beams of like state of polarization;

directing the beams separately through a series of stages, each of which include separate non-birefringent optical path segments which introduce predetermined optical path length differences that are substantially constant over a selected temperature range, such that after each stage the beams possess frequency varying transfer functions derived from the optical path length differences of the stages, wherein the transfer functions of the individual stages have integer related frequency periodicities at precise phase relationships;

separating the beams into four components; and

combining the four components into two polarization independent output beams having complementary, frequency periodic transfer functions.

92. The method as set forth in claim 91 above, wherein the phase relationships between the stages have relative phases of either 0° or 180°.

93. The method as set forth in claim 91 above, wherein the non-birefringent optical path segments are non-birefringent and arranged in pairs, with the lengths, refractive indices and thermooptic properties related to provide the desired athermal characteristic.

94. The method as set forth in claim 91 above, wherein the non-birefringent path segments comprise delay lines of different optical path lengths.

95. The method as set forth in claim 91 above, wherein the step of directing the beams separately through a series of stages include equalizing the lengths of the paths

between the non-birefringent optical path segments.

96. The method of utilizing polarization interference to introduce a periodic frequency and interleaved response to DWDM optical signals in an input beam, comprising the steps of:

splitting the input beam into orthogonally polarized first and second beams;

rotating at least one of the first and second beams to states of identical polarization at a selected first angle;

splitting the first and second beams to provide displaced third and fourth beams that are polarized at orthogonal relationships to the non-displaced residual first and second beams;

applying different wavelength dependent retardation delays to the first and second beams than the third and fourth beams by propagation through paths having selectively different optical path lengths;

converting the states of polarization of the beams to circular polarization along the beam path lengths;

preserving the circular polarizations while phase tuning the different beam pairs;

converting the first, second, third and fourth beams, respectively, to linearly polarized and orthogonal states, the directions being 90° different from the directions of polarization immediately prior to retardation delays;

combining the first and third beams, respectively, and the second and fourth beams, respectively, to provide individual beams having periodic, wavelength dependent states of polarization, and

deriving intensity modulated output signals having frequency dependent transmission characteristics.

97. The method as set forth in claim 96 above, further including the step of repeating at least once the sequence of steps including the splitting of beams, applying different retardation delays, and introducing different phase tuning.

98. The method as set forth in claim 95 above, wherein the step of phase tuning is performed in association with the application of differential delays.

99. The method as set forth in claim 95 above, wherein the step of phase tuning is performed independently of the application of differential delays.

100. In an optical signal interleaver employing at least one birefringent polarization beam splitter and at least one differential delay stage for providing, by interferometric operation, transmittance passbands centered on frequencies in an ITU grid, the method comprising the steps of:

directing an optical beam having multiple frequency components through the at least one polarization beam splitter into the differential delay stage, and

varying the angle of the beam relative to the at least one polarization beam splitter to adjust the frequency period of the transmittance passbands derived from the at least one stage.

101. In an optical signal interleaver in which differential delays in optical elements are employed to derive, from wavelength division multiplexed input signals, output signals in a different multiplexed format that have frequencies aligned with standards in an ITU grid, the method comprising the steps of:

in association with the optical elements, providing at least two beam components subject to the differential delay;

generating circular stages of polarization in the at least two beam components, and

separately adjusting the polarization vectors of the at least two beam components to vary the phases of the beams such that the output signals match the frequencies of the ITU grid.

102. A method in accordance with claim 100 above, wherein the interleaver generates two beam pairs, to be differentially delayed, the beams of each pair being displaced from each other but also paired individually with a different beam form the other pair, wherein the method further comprises the step of separately adjusting the angles of the polarization vectors for the individually paired beams from the two different beam pairs.

103. An interleaver device for optical signal communications, comprising:

a planar surface bench structure having an array of mounting pads disposed along a longitudinal axis along the plane of the surface;

at least two differential retardation stages in series and each comprising glass elements mounted on the pads along the longitudinal axis, the glass elements being elongated rectangular elements with their axis of elongation parallel to the longitudinal axis, the glass elements of each stage being arranged in side by side relation to provide two separate beam paths for differential retardation, with close longitudinal abutment of glass elements serially disposed in any individual stage;

at least one waveplate combination disposed between each successive pair

of stages for adjusting phase relationships;

at least two polarization beam splitters disposed along the longitudinal axis, the polarization beam splitters being positioned to selectively divide and/or combine beams between the stages, dependent on beam direction;

a single optical waveguide coupled to one end of the series of retardation stages;

a separate pair of optical waveguides coupled to the series of retardation stages at the opposite end thereof; and

a pair of polarization beam splitters serially disposed along the longitudinal axis between the said opposite end of the stages and the pair of waveguides.

104. An interleaver device as set forth in claim 103 above, for bi-directional operation as either a multiplexer or demultiplexer, wherein the glass elements are arranged in the stages to have unlike optical path lengths for each of the two beam paths and wherein the stages each have an integer number of glass elements arranged in series in each of the two separate paths.

105. An interleaver device as set forth in claim 104 above, wherein the device further comprises a beam collimator disposed between the beam path and the optical waveguide at the one end, and an optical combination at said opposite end comprising at least two polarizing beam splitters disposed in series, separate folding optics for redirecting the two beams and beam collimators communicating beams individually to the pair of optical waveguides.

106. A waveplate combination for a multistage optical interleaver having target transmission peaks for a wavelength multiplexed signal, each stage of the interleaver

generating differential retardance for first and second pairs of optical beams of orthogonal polarization comprising:

a first quarter waveplate oriented at plus or minus 45° to the polarization axis of the optical beams;

a first half waveplate disposed in the paths of the first two optical beams and adjacent the quarter waveplate, and rotatable with respect to the polarization axis to adjust the absolute frequencies of the interleaver transmission peaks to match the target peaks;

a second half waveplate disposed in the paths of the remaining two optical beams and adjacent the quarter waveplate and rotatable with respect to the polarization axis to adjust the absolute frequencies of the interleaver transmission peaks to match the target peaks; and

a second quarter waveplate oriented at minus 90° to the first quarter waveplate to convert the first and second pairs of optical beams to linear states of polarization.

107. A waveplate combination as set forth in claim 102 above, wherein the optical beams generating differential retardance comprise four parallel beams in quadrants arranged as two pairs, each with orthogonal polarizations.

108. A waveplate combination as set forth in claim 107 above, wherein the first quarter waveplate converts the orthogonally polarized beams to circular states of polarization.

109. An interleaver optical filter component dividing an input multi-wavelength beam into interleaved multiple even channels and multiple odd channels and including separate retardation stages, the polarization rotators being configured to provide beam

angles into the retardation stages such that the desired optical transmission response is synthesized.

110. An interleaver optical filter component in accordance with claim 109 above, wherein the polarization rotators comprise input waveplates arranged to rotate the polarizations of both beams to selected angles before entering the filtering stages such that even channels exhibit approximately quadratic group delay characteristics of opposite sign to the odd channels.

111. An interleaver optical filter component in accordance with claim 109 above wherein the retardation stages exhibit relative phases configured such that the even channels exhibit approximately quadratic group delay characteristics of opposite sign to the odd channels.

112. An interleaving optical filter arrangement in accordance with claim 109 wherein a compensating pair of interleaver optical filter components are disposed in the channels and configured to operate in series combination to provide zero chromatic dispersion in transmission through the pair.

113. An interleaving optical filter in accordance with claim 97 wherein the filtering stages consist of synthetic birefringent elements utilizing two glass delay line elements, wherein the glass elements are of nominally equal lengths and exhibit compensating temperature dependencies such that the optical frequency periodicity of the interleaver drifts by less than +/-1.5 GHz over the operating temperature range of 0 to 70°C.